Anesthetic Considerations For Robotic Surgery

Warning Will Robinson, Warning

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Learner Outcomes

1. Discuss the history of robotic surgery.
2. Summarize the pathophysiologic effects of positioning and pneumoperitoneum for robotic surgery.
3. Summarize the peri-operative anesthetic management for robotic surgery.
4. Discuss procedure specific anesthesia-related complications related to robotic surgery.

Robots

Definition

- Describes an autonomous device capable of various tasks
- Industrial robots
- Stereotactic navigation assist device.
- Telemanipulators
History

Joseph Capek-1917
• Opilec

Karel Capek-1921
• Rossum’s Universal Robots (RUR)

Isaac Asimov 1938-1942

Gm Introduces Unimate-1958

History

- Nasa Developed Robots For Space
- Telemanipulators Capable Of Doing Manual Tasks
  - Slave Devices Were Controlled Electronically From A Remote Console
  - Dexterous Telemanipulators For Surgical Use

Department Of Defense Investigates Robots For Treating Battlefield Wounded

- Latency Of The Signal Over Distance Limited Its Effectiveness

1985-First Surgical Application Using Modified Industrial Robotic Arm
Laparoscopy

Phillipe Mouret - 1987

• First Video Laparoscopic Cholecystectomy

Advantages

• Reduced Tissue Trauma
• Reduced Postoperative Pain
• More Rapid Recovery
• Shorter Hospital Stay
• Improved Patient Satisfaction

Robodoc - 1992

• Used In Orthopedics
• Fulcrum Effect
• Non-Intuitive Motion Of The Instrument Tips In Opposite Direction About A Fixed Point

Aesop And Tiska Endoarm

1994

Development of Active Robotics

• Overcoming Dexterity Problems
• Development Of Manipulators That Mimick Hand Movements
• Development Of Three Dimensional Video Imaging, Robot Camera Holders And Robotic Flexible Instrumentation
• Ability For Tactile Pressure Sensation
Two Robotic Systems

First Robotic-Assisted Surgical Procedure
April 1997

Jacques Himpens
Guy Cardiere

da Vinci Systems

The da Vinci Robotic Surgical System

da Vinci S
da Vinci Xi
da Vinci

Single Site Cannulation

Firefly Fluorescence Imaging

On The Horizon

da Vinci Sp (Investigational Trials)

How Big Is Robotics?

Utilization

Source: ISI data and estimates
Robotics and Procedure Type

Advantages of Robotic Surgery

- Magnified 3D Vision
- Digitalized Hand Movements
- Superior Maneuverability Of Robotic Instruments
- Safety System Prevents Un-Attended Movement Of Arms

Cost To The Institution

Disadvantages Of Robotic Surgery

- Bulky, Large Equipment
- Costly
- Instrumentation Has Finite Life Of Ten Procedures
- Invasion Of Anesthetic Work Space
- Loss Of Tactile Feedback
- Requires Staff Training
Initiating A Robotic Program

- Major Financial Outlay And Recurring Cost
- Surgical Growth Potential And Recognition Offsets The Cost Of The Program
- Teamwork Is Essential To Success
- Challenges Include
  - Increased Operating Time
  - Surgical Learning Curve

Procedures Performed Using Robotics

Urologic Procedures Include
- Pyeloplasty
- Cystectomy With Diversion
- Adrenalectomy
- Radical And Partial Nephrectomy
- Radical Prostatectomy

Prostate Cancer

- Affects 235,000 Annually
- Death Rate Approximates 12%
- Treatment Options Include:
  - Radiation
  - Observation
  - Surgery

Radical Prostatectomy

- Changes Quality Of Life
- Discourages Treatment
- Complications From Damage To Urinary Sphincter And Penile Nerve
- Minimally Invasive Technique
  - Nerve-Sparing Technique
  - Has Increased Patient Acceptance
  - Allows More Rapid Discharge
Procedures Performed Using Robotics

- GI Procedures
  - Cholecystectomy
  - Gastric Bypass, Pancreatoduodenectomy
  - Colon Resection
- Thoracic
  - Lobectomy And Wedge Resection
  - Esophagectomy
  - Thymectomy
- Cardiac
  - Coronary Bypass Graft
  - Atrial Septal Defect Repair
  - Mitral Valve Replacement
- Thyroidectomy
- Orthopedics
- Ophthalmology
- ENT

Differences Between Robotic And Laparoscopic Surgery

- Challenges To Patient Access
- Securing And Preventing Patient Movement
- Importance Of Adequate Muscle Relaxation

Anesthesia Considerations

- Patient Positioning
- Hemodynamic And Respiratory Effects Of Pneumoperitoneum
- Duration Of Procedure
- Spatial Restrictions Due To Equipment
- Possibility Of Unsuspected Visceral Injury Or Blood Loss
- Development Of Hypothermia

Positioning

- Robot May Be Positioned At The Foot, Side Or Over To Head
- Once Robot Is Engaged, Bed And Patient Position Cannot Be Changed
- Protect The Patient From Pressure And Crush Injuries From Robotic Arms
Protecting Your Patient From Nerve Injury

- 2.7% Incidence Of Neuromuscular Injury Annually
  - Radial And Ulnar Nerves
  - Brachial Plexus
  - Sciatic Nerve
  - Obturator Nerve
  - Peroneal Nerve
  - Lateral Femoral Cutaneous Nerve
- Pad All Areas
- Patient Strapped With Chest Binding In X Pattern

Positioning In Trendelenburg

- Protective Mat Placed Under Patient To Minimize Slipping And Provide Padding
- Bean Bag Is An Option But Rarely Used
- Avoid Use Of Shoulder Braces

Positioning In Lithotomy

- Goal Is To Minimize Hip Abduction And Maximize Flexion To Accommodate Robot Arms
- Cushioned Stirrups
- Arms And Hands Padded And Tucked
- Ensure Iv Access And Functional Monitoring Ability
- Only Opportunity To Gain Access For Iv's And Invasive Monitors Is Before Docking

Positioning In Lateral Position

- Axillary Roll Placed
- Kidney Rest Positioned Over Iliac Crest
  - Prevents Lung Splinting And Atelectasis
- Plan On Variations Of Trendelenburg Or Reverse Trendelenburg
Effects Of Trendelenburg

- Abdominal Contents Push Diaphragm Cephalad
- Increased Pulmonary Blood Content And Gravitational Force On Mediastinal Structures
- Swelling Of Face, Eyelids, Conjunctivae, And Tongue
  - Pharyngeal And Laryngeal Edema Is Possible

Cardiovascular Effects of Trendelenburg

- Increased CVP, Myocardial Work And Pulmonary Vascular Resistance
- Increased SV, CO
- Map Unchanged Or Slightly Increased
- Increased Cerebral Venous Pressure
  - Decrease In CBF

IOP and Trendelenberg

- Dorzolamide Hydrochloride And Timolol Maleate (Cosopt) Reduced Elevated Iop During Steep Trendelenberg

Molloy, B. AANA Journal, Apr. 2011; Jun 2014
Effects Of Pneumoperitoneum

- Well Tolerated By Health Individuals
- Myriad Of Issues
  - Cardiovascular Effects
  - Pulmonary Effects

Cardiovascular Effects Of Pneumoperitoneum

- Increase In Intraabdominal Pressure Causes:
  - Compression Of Vena Cava
  - Increase In SVR, MAP, HR, PVR
  - Increase In CVP, PCWP, PAP
  - Decrease In SV, CO, CI
- Pronounced In Patients With Pre-Existing Disease

Pulmonary Effects Of Pneumoperitoneum

- Elevation Of Diaphragm
- Decreased Frc
- Peak Pressure, Plateau Pressure And Intrathoracic Pressure Increase By More Than 50%
- Decreased Compliance Up To 68%
- V-Q Mismatch
- Pulmonary Shunting
- Co2 Absorption Hypercarbia And Acidosis Corrected With Ventilation

Comparative Effects

<table>
<thead>
<tr>
<th>Trendelenburg</th>
<th>Pneumoperitoneum</th>
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<tbody>
<tr>
<td>↑ SV</td>
<td>↓ SV</td>
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<tr>
<td>↑ CO</td>
<td>↓ CO</td>
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<td>↑ CVP</td>
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<tr>
<td>± MAP or slightly ↑</td>
<td>↑ MAP</td>
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<tr>
<td>↓ FRC</td>
<td>↓ FRC</td>
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<tr>
<td>↓ Compliance</td>
<td>↓ Compliance</td>
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<tr>
<td>↓ CBF, ICP</td>
<td>↑ CBF, ICP</td>
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Combined Effects Of Pneumoperitoneum And Trendelenburg

- MAP Decreased 17%
- HR Decreased 21%
- CO Decreased 10-30%
- 27% Of Patients Experience Dysrhythmias

Hepatic Effects Of Pneumoperitoneum

- Decreased Portal Vein Flow
- Decreased Hepatic Vein Flow
- Decreased Total Hepatic Blood Flow And Flow Through Hepatic Microcirculation
- No Change In Hepatic Arterial Flow

GI And Renal Effects Of Pneumoperitoneum

- Decreased Gastric PH
- Decreased Mesenteric Blood Flow And Microcirculation
- Decreased Renal Blood Flow

CNS Effects Of Pneumoperitoneum

- Increased CBF
- Increased ICP
- Decreased CPP
Complications Of Pneumoperitoneum

- Subcutaneous Emphysema
- Pneumothorax
- Cephalad Shift Of Diaphragm
- Venous Gas Embolism

Venous Gas Embolism

Caused By Rapid Insufflation Into Vessel
- Mill-Wheel Murmur
- Hypoxia
- Decreased CO²
- Cyanosis
- Sudden Cardiac Collapse

Treatment
- Removal Of Pneumoperitoneum
- Hyperventilation With Oxygen
- Left Lateral Decubitus And Trendelenburg Position
- Aspiration Of Air Via CVP

Anesthesia Management

- Everyone Is Not A Candidate
- Proper Screening Will Minimize Complications Of Positioning And Pneumoperitoneum

Pre-Operative Evaluation

- Optimization Of Cardiorespiratory And Metabolic System
- Discontinuation Of Anti-Coagulants
- Identify Past History Of Abdominal Surgery
- Document Pre-Existing Nerve Injury
Obesity And Robotics

- Predisposed To HTN, CAD, DM
- Challenge On Pulmonary Physiology
- Hindrance On Diaphragmatic Movement
- Difficulty Achieving Minute Ventilation

Intra-Operative Management

- No Specific Technique Or Drug Preference
- Standard Monitors
  - Consider Arterial Line Placement
  - Regional Anesthesia Not Indicated

Ventilation

- Increase In Airway Pressures
- Augmented In Patients With Restrictive Or Obstructive Disease
- Utilize Pressure Controlled Ventilation Provides Better Ventilation And Lower Peak Airway Pressures Over Volume Control Mode

Muscle Relaxation

- Complete Muscle Relaxation Is Essential
- Spontaneously Breathing Diaphragm Causes Abdominal Contents To Move
- Facilitates Ease Of Mechanical Ventilation
- Facilitates Introduction Of Surgical Equipment
- Eases Creation Of Pneumoperitonium
- Consider Using Continuous Infusion
Special Considerations

Anesthetic Considerations For Robotic-Assisted Thoracoscopy

- Same Principles Apply As Thorascopic Surgery
- Improved Patient Outcome
- Selection Criteria Limited
- Side Cart Is Positioned Close To Head
- Limited Access To Airway And Neck

Anesthetic Considerations For Robotic-Assisted Thoracoscopy

- Insufflation Of CO₂ In The Chest Increases Airway Pressures
- Venous Return And Compliance Of Heart Decreases Resulting In:
  - Hypotension And Hemodynamic Instability
  - Dependent Lung Develops Higher Airway Pressures
  - CO₂ Rapidly Absorbed

- One Lung Ventilation And Manipulation Alter Ventilation And Perfusion
- Lateral Position Reduces Shunting To Non-Dependent Lung
- Pulmonary Shunting In Non-Ventilated Lung Limited By HPV
Complications Of Thoracic Insufflation

- Emergency Conversion To Open Procedure
- Contra-Lateral Pleural Can Be Violated Creating Tension Pneumothorax In Dependent Chest
  - $CO_2$ Discontinued To Alleviate Tension Pneumothorax

Gynecologic Surgery

- Marked Improvement Over Laparoscopic Procedures
- Improved Micro-Surgical Techniques

Fluids

- Minimizes Facial Edema
- Restricted To Prevent Obscuring Surgical Field During Resection Of Bladder Neck
- Restoration Of Volume Possible After Return To Supine Position

"Mr. Osborne, may I be excused? My brain is full."
Summary

• Learning Curve For The Surgeon
• Positioning And Pneumoperitoneum Provide A Great Challenge
• Robotics Gives New Meaning To Field Avoidance
• Patient Satisfaction And Surgical Outcomes High
• Much More Lies Over The Horizon

Warning, Will Robinson, We're Being Taken Over By Robots!